



MERC/TPR-76/7

LITHOLOGIC DESCRIPTION OF CORED WELLS
#11940 and #12041 IN THE DEVONIAN
SHALE IN THE COTTAGEVILLE, WEST VIRGINIA
AREA

By

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Date Published - October 1976

MORGANTOWN ENERGY RESEARCH CENTER
MORGANTOWN, WEST VIRGINIA

UNITED STATES ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
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Lithologic Description of Cored Wells #11940
and #12041 in the Devonian Shale in the
Cottageville, West Virginia Area

Cored Well #11940

Cored Intervals: 3410'-3500'
3600'-3794'

and

Cored Well #12041

Cored Interval: 3220'-3690'

by

C.W. Byrer, D.B. Trumbo, S.J. Rhoades

Morgantown Energy Research Center
Morgantown, West Virginia

October 1976

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Lithologic Description of the Devonian Shale in the Cottageville, West Virginia Area

INTRODUCTION

This report presents a detailed lithologic description of the Devonian Shale as observed in cores taken in Jackson County, West Virginia. The cored well (E.L. Bailer #11940) is located approximately five miles southwest of the town of Cottageville, West Virginia (Figure 1). The second cored well (W.L. Pinnell #12041) is located three miles west of Cottageville, West Virginia (Figure 1).

PURPOSE

The purpose of the cored wells is to characterize in detail the Devonian Shale in the western portion of West Virginia. Analysis of the core material will provide information to be used in designing stimulation techniques for the improvement of gas production from the Devonian Shale. The core data will be used in designing an experiment to drill a well directionally deviated to intercept an optimum number of natural fractures that exist in high hydrocarbon zones within the shale reservoir in this area of western West Virginia. Specifically, the core data will locate and characterize those zones of brown shale with high hydrocarbon content. The lithologic information will correlate stratigraphically these zones in a particular area of the Appalachian Basin. The well will be deviated to an inclination of 60° and then be stimulated by multiple stage hydraulic fracturing in an effort to improve the rate of recovery of gas from the shale and the total amount of reserves assigned to a single well.

GENERAL GEOLOGY

The general surface geology of the area contains rocks of the Permian Age (Figure 2). The Gilmore Sandstone is the summit of the Dunkard Group and this massive sandstone caps many ridges in northeastern Jackson County. The Upper, Middle, and Lower Rockport Limestones are also cap rocks in Jackson County. Other prominent surface rocks include the Nineveh Sandstone and the Upper and Lower Marietta Sandstones (steep hill cliffs). The Dunkard Coal is a very thin impure coal seam in this series. The Nineveh coal is also thin but a better grade of coal.

The Monongahela Formation is the highest formation of the Pennsylvanian Series. It is also the most economically significant of any group in the Pennsylvanian Series. The Waynesburg, Sewickley, and Redstone Coals are other economically valuable units in the Monongahela Formation. The Pittsburgh Coal is the lowest (last measure) of this series, and it is economically the most valuable. The Conemaugh formation contains the Connellsville Sandstone, Saltsburg Sandstone, Bakerstown Coal, and the Upper Mahoning Sandstone. The Lower Freeport

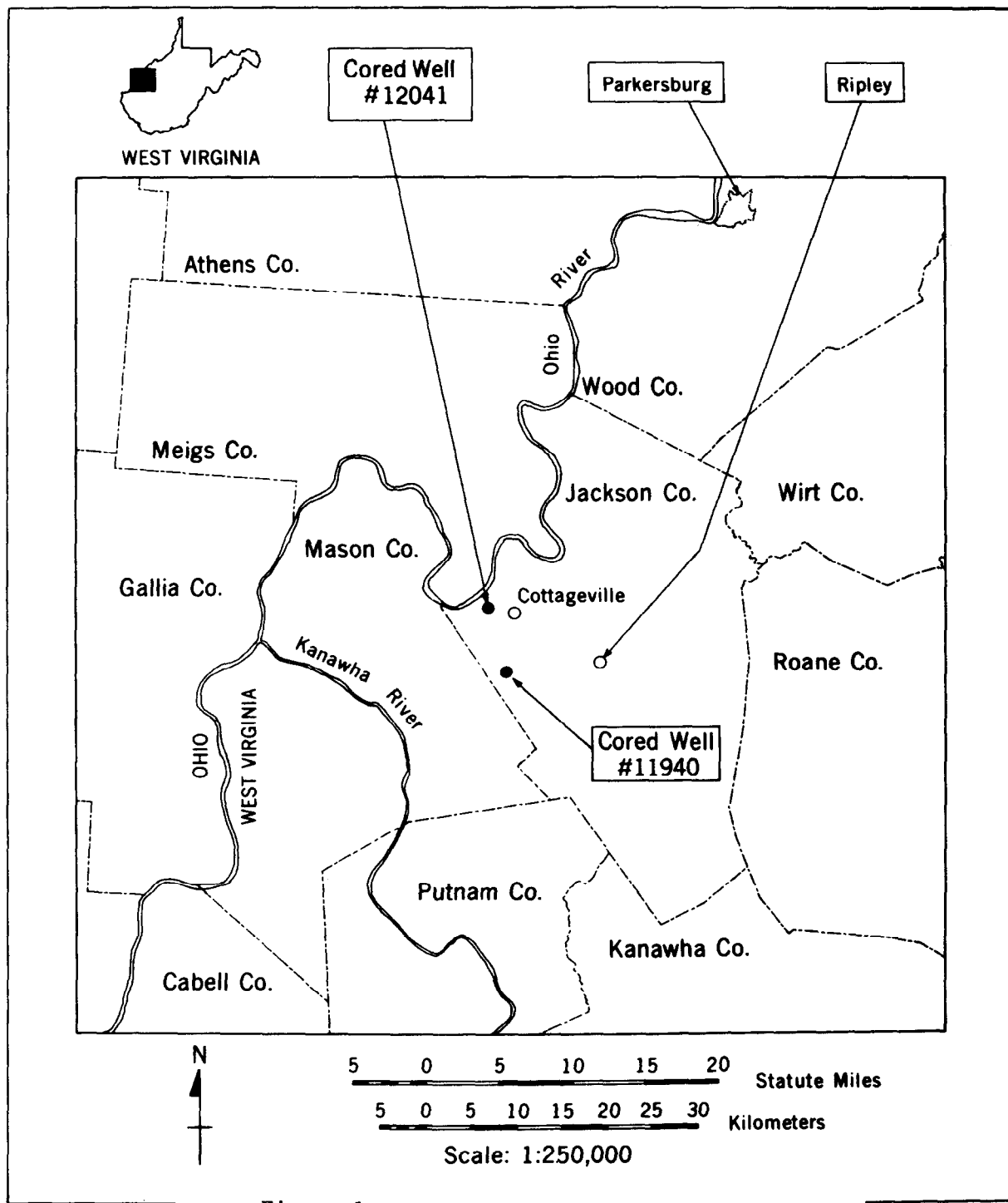


Figure 1 - Location of Cored Wells

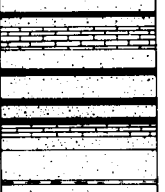

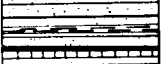





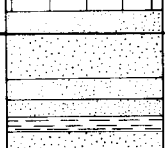
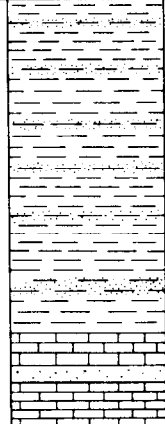
GENERALIZED GEOLOGIC COLUMN				
SERIES	GROUP OR FORMATION	IMPORTANT ROCK UNITS	ROCK COLUMN	DRILLERS TERMS
PERMIAN	DUNKARD	Gilmore SS Rockport LS Nineveh Coal Dunkard Coal Jollytown Coal Upper Marietta SS		Gilmore Coal Nineveh Sand Jollytown Sand Hundred Sand Washington Coal
PENNSYLVANIAN	MONONGAHELA	Waynesburg Coal Sewickley Coal Pittsburgh Coal		Uniontown Coal Redstone Coal
	CONEMAUGH	Connellsville SS Bakerstown Coal Mahoning SS		Morgantown Sand Saltsburg Sand
	ALLEGHENY	Lower Freeport SS		Burning Springs Sand Gas Sand
	POTTSVILLE	Salt Sands		1 st Salt Sand 2 nd Salt Sand 3 rd Salt Sand
MISSISSIPPIAN	MAUCH CHUNK	Maxton SS		Ravencliff Sand Lower Maxon Little Lime
	GREENBRIER	Greenbrier Limestone		Big Lime Keener Sand
	POCONO	Squaw SS Weir Sand Berea SS		Sunbury Shale
DEVONIAN	HAMPSHIRE CHEMUNG	Fifty-foot SS Gordon SS Fifth Sand Speechley Sand Balltown Sand Benson Sand Onondaga LS		BROWN SHALE Corniferous LS Oriskany Sand
	MILLBORO (MARCELLUS) SHALES HELDERBERG	Helderberg LS		

Figure 2 - Generalized Geologic Column
of Area

Sandstone and Second Cow Run Sand are the more prominent units in the Allegheny Formation. The Pottsville Formation has several Salt Sands (1st, 2nd, and 3rd).

The Mauch Chunk Formation is at the top of the Mississippian Series. The most prominent unit of the Mauch Chunk is the Maxton Sandstone. The Greenbrier Formation contains the Big Lime (West Virginia) and the Keener Sandstone. The lowest formation of the Mississippian Series is the Pocono. Prominent units within this formation are the Big Injun, Squaw, and Berea Sandstones.

The Devonian Series has several units pertinent to this study. The Upper Devonian contains the Hampshire Group with the Fifty Foot Sandstone, Gordon Sandstone, and Fifth Sand. The Brown Shale of West Virginia is found in the Upper and Middle Devonian along with the Speechley, Balltown, and Benson Sandstones. The Lower Devonian contains the Onondaga Limestone, Oriskany Sandstone, and Helderberg Limestone.

SUMMARY

The core sections being studied are of Devonian Brown Shale from two wells in the Cottageville, West Virginia area (E.L. Bailer #11940 and W.L. Pinnell #12041). The total thickness of the Brown Shale in this region is approximately 900'.

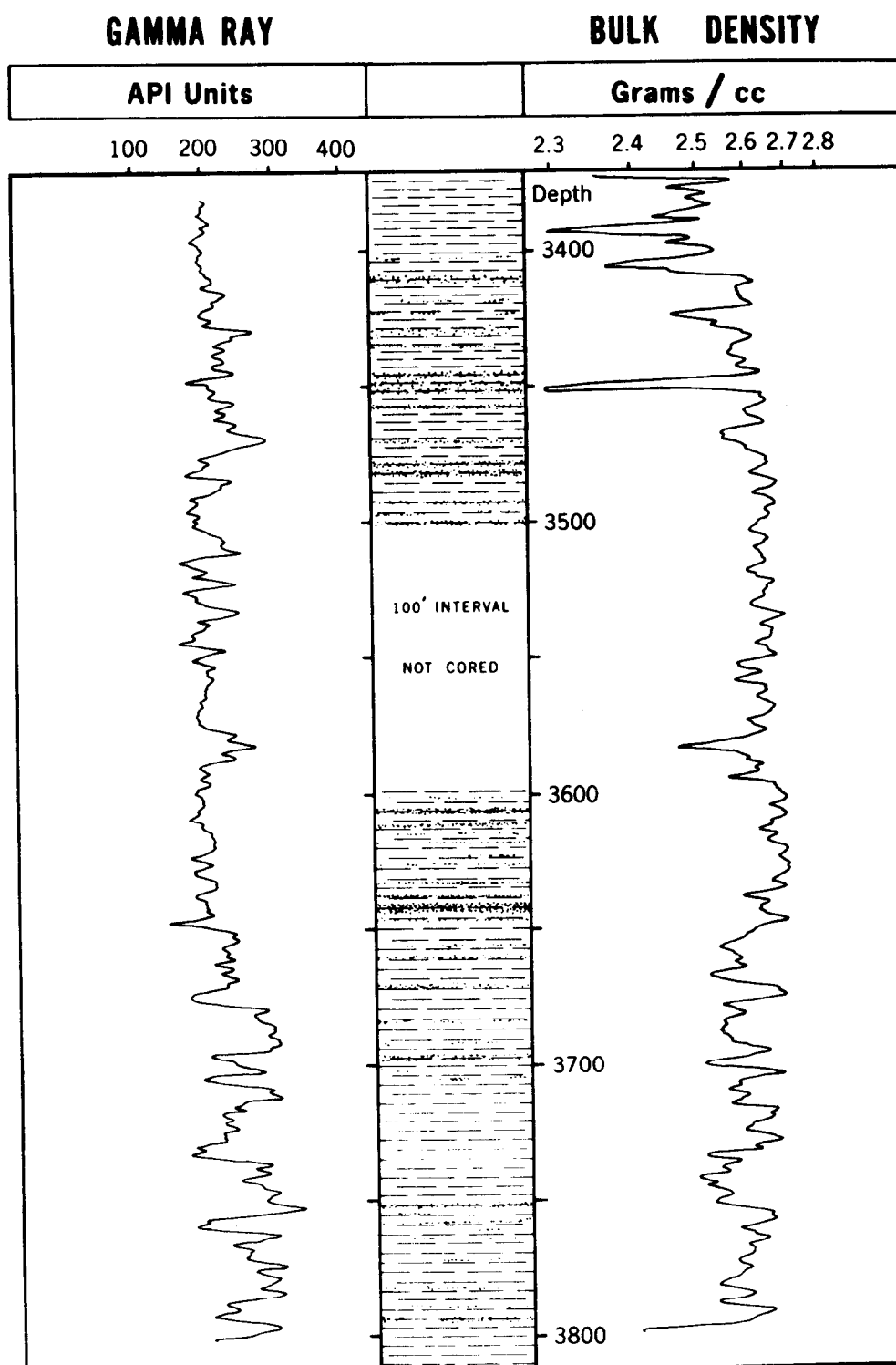
Two cored sections from the E.L. Bailer #11940 well were examined (Appendix A). The top of the first cored section is 3410' and the bottom of the core is 3500' (Figure 3). The top of the second cored section is 3600' and the bottom of the core is 3797'. The total length of core obtained is 287'.

The analysis of the upper section (3410'-3500') shows that the shale is medium grey (N-5) to dark grey (N-3) in color with numerous pyritic nodules, silty stringers, spore casts, and carbonaceous fossil fragments throughout the core. The trend of the vertical fractures in both core sections shows a major orientation striking N 47°E. Also 60° oblique fractures occur throughout the entire core section with some fractures becoming vertical.

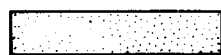
The lower section (3600' to 3797') is medium dark grey (N-4) to dark grey (N-3) with silty stringers, pyrite nodules, spore casts, and carbonaceous fossil fragments throughout. Mineral filled fractures are concentrated at 3720' to 3730', and a few fractures are scattered toward the bottom of the section. The gamma ray log shows zones of high radioactivity between 3426'-3470' and also between 3676'-3784' (Figure 3)

A core from the W.L. Pinnell #12041 well was also studied (Figure 1). The top of the cored section is 3220 feet and the bottom of the core is 3690.0 feet. The total length of the core is 470 feet (Figure 4).

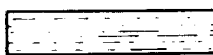
The analysis of this cored well (Appendix B) shows that the shale has few natural fractures. There are many silty zones and silty laminations throughout this shale zone. Most of the Brown Shale interval was medium dark grey (N-4) and dark grey (N-3). There are numerous zones



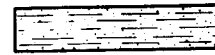
LEGEND



Sandstone



Shale

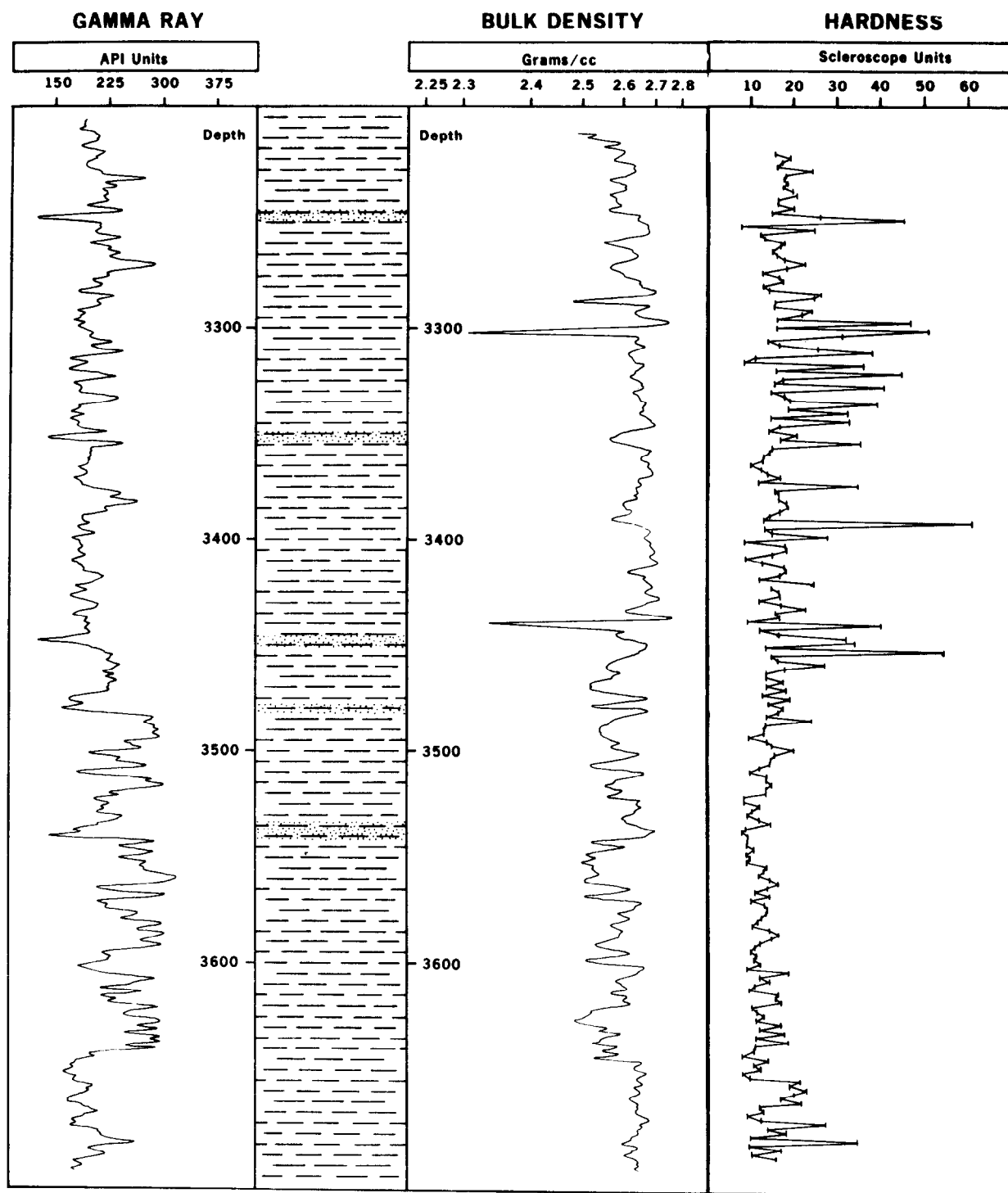


Siltstone

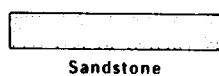
Figure 3 - Logs of Core Well #11940

of alternating thin laminations of medium dark grey and dark grey shale. Differential loading effects are evident throughout the core, and the smell of kerogen material is also present. The natural and induced fractures which were recorded in the analysis show a trend striking along N 65°E.

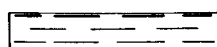
The gamma ray log shows areas of high radioactivity at 3275 feet, 3380 feet, and the zone between 3490 feet - 3640 feet. The bulk density log and the hardness test results are also shown, and those intervals at 3300 feet and 3440 feet show possible correlations (Figure 4).



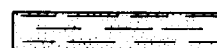
LEGEND



Sandstone



Shale



Siltstone

Figure 4 - Logs of Core Well #12041

APPENDIX A

COTTAGEVILLE, W. VA. #11940

Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3410.0 -3412.3 (2.3)	Shale, banded indiscriminantly from medium dark grey to medium grey (N-4 to N-5), clayey, micaceous, occasional 1 mm discontinuous calcareous silty stringers. 3 fractures @ N 45° E.	3439.15 -3442.0 (2.85)	Shale, same as above. 1 fracture @ N 45° E.
3412.3 -3415.05 (2.75)	Shale, same as above, with thinly laminated calcareous zones about 2 cm thick @ 3414.1 and 3414.8, occasional pyrite nodules 1 mm in diameter. 1 fracture @ N 53° E.	3442.0 -3444.75 (2.75)	Shale, banded, medium dark grey to medium grey (N-4 to N-5), clayey, micaceous, silty non-calcareous zones up to 4 cm wide, occasional carbonaceous fossil fragments. 2 fractures @ N 60° E, and N 55° E.
3415.05 -3415.9 (.85)	Shale, medium dark grey (N-4), clayey, micaceous, occasional 3 mm non-calcareous silty stringer. 1 fracture @ N 48° E.	3444.75 -3446.2 (1.45)	Shale, medium dark grey (N-4), clayey, micaceous, uniform throughout interval. 2 fractures @ N 55° E.
3415.9 -3417.8 (1.9)	Shale, same as above, very uniform with few lithologic features.	3446.2 -3447.3 (1.1)	Shale, medium dark grey to medium grey (N-4 to N-5), banded, silty non-calcareous zones 3 cm wide, micaceous. 1 fracture @ N 50° E.
3417.8 -3420.6 (2.8)	Shale, same as above, with addition of occasional thin stringers, occasional pyrite spheres (2 mm) and a 2 cm laminated calcareous zone @ 3419.1. 1 fracture @ N 45° W and 1 at N 50° E.	3447.3 -3448.4 (1.1)	Silty zone, medium grey (N-5), calcareous zone @ 3448.15 4 cm thick.
3420.6 -3423.5 (2.9)	Shale, banded indiscriminantly with medium dark grey to medium grey (N-4 to N-5), clayey, micaceous, occasional silty stringer, large carbonaceous fossil fragment with mineral filled fractures (calcite) @ 3423.25. 1 fracture @ N 45° E.	3448.4 -3450.0 (1.6)	Shale, banded, medium dark grey to medium grey (N-4 to N-5), 1 cm zone of pyrite nodules @ 3448.5, micaceous, occasional small (1 mm) silty stringer. 2 fractures @ N 50° E.
3423.5 -3426.05 (2.55)	Shale, same as above.	3450.0 -3452.45 (2.45)	Shale, same as above, prominent .5 to 2 cm wide, silt layers, frequent cross-bedding in silt layers observed at ≈ 3451.1.
3426.05 -3428.7 (2.65)	Shale, same as above, with frequent laminated calcareous silty zones as wide as 8 cm.	3452.45 -3454.9 (2.45)	Shale, same as above, occasional spore casts with microcrystalline pyrite replacement. 1 fracture @ N 55° E, and 1 @ N 50° E.
3428.7 -3431.2 (2.5)	Shale, medium dark grey (N-4), clayey, micaceous, occasional small carbonaceous fossil fragments, occasional large spore casts, 4 cm calcareous silty zone at 3430.4. 1 fracture @ N 45° E and 2 @ N 55° E.	3454.9 -3457.8 (2.9)	Shale, same as above, cross-bedded silt at 3456.0. 1 fracture @ N 50° E.
3431.2 -3434.2 (3.0)	Shale, medium dark grey (N-4), clayey, micaceous, uniform character with thin discontinuous calcareous silty stringers throughout interval. 1 fracture @ N 45° E, 1 @ N 50° E, and 1 @ N 52° E.	3457.8 -3460.0 (2.2)	Shale, same as above, cross-bedded silt layer @ 3459.1. 1 fracture @ N 45° E.
3434.2 -3436.3 (2.1)	Shale, same as above. 1 fracture @ N 60° E, and 1 @ N 57° E.	3460.0 -3463.0 (3.0)	Shale, same as above, calcareous silt zone 5 cm thick @ 3462.2. 1 fracture @ N 55° E, and 1 @ N 80° W.
3436.3 -3439.15 (2.85)	Shale, same as above. 1 fracture @ N 48° E, and 1 @ N 51° E.	3463.0 -3465.55 (2.55)	Shale, same as above, banding beginning to decrease in frequency. 1 fracture @ N 20° E, 1 @ N 50° E, and 1 @ N 48° E.
		3465.55 -3466.0 (1.45)	Shale, same as above. 1 fracture @ N 50° E, 1 @ N 15° E.
		3466.0 -3467.4 (1.4)	Shale, medium dark grey (N-4), clayey, micaceous, spore casts with pyrite replacement are common. 1 fracture @ N 15° E.

COTTAGEVILLE, W. VA. #11940

Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3467.4 -3470.0 (2.6)	Shale, same as above with a 2 cm cross-bedded silty calcareous zone at 3467.9. 2 fractures @ N 70° E, and 1 @ N 45° E.	3494.3 -3497.0 (2.7)	Shale and siltstone, same as above, occasional cross-bedding, .7 ft. calcareous silt zone at 3494.5. 2 fractures @ N 40° E.
3470.0 -3470.6 (.6)	Shale, medium grey to medium dark grey (N-5 to N-4), clayey, micaceous, frequent spore casts replaced with microcrystalline pyrite.	3497.0 -3500.0 (3.0)	Siltstone and shale, same as above, some are calcareous--some are not, occasional cross-bedding and loading features, some "iron-staining" of siltstone near 3500.00. 5 fractures @ N 45° E.
3470.6 -3473.0 (2.4)	Shale, medium dark grey (N-4), clayey, micaceous, non-calcareous silt layer 3 cm thick @ 3471.5, occasional pyrite nodule.	3500.0 -3601.8 (1.8)	Shale (N-4), medium dark grey to greenish-grey (5 GY 6/1), light banding with silty calcareous stringers 1" at ~ 3601.0 clayey and slightly micaceous. 2 fractures @ N 45° E.
3473.0 -3475.8 (2.8)	Shale, banded, medium dark grey to medium grey (N-4 to N-5), silt layers up to 6 cm thick throughout, non-calcareous, micaceous, occasional pyrite nodules. 1 fracture @ N 55° E.	3601.80 -3604.57 (2.77)	Shale, (N-4) medium dark grey to greenish-grey, indiscriminate silty stringers (non-calcareous), some with Fe stain. Traces of drusy pyrite in section. 1 fracture @ N 45° E.
3475.8 -3478.3 (2.5)	Shale, same as above. 2 fractures @ N 50° E.	3604.57 -3607.0 (2.43)	Shale, (N-4) medium dark grey with bands of N-3 indiscriminately found (2"). A silty zone 4-5" is found (very calcareous) at 3605.20. Small pelecypods .02 mm are scattered throughout with casts and pyrite replacement. 2 fractures @ N 45° E.
3478.3 -3481.3 (3.0)	Shale and silt, same as above. Silt layers constitute 50% of interval, 12 cm zone of calcareous silt @ 3480.0, stringer of pyrite nodules @ ~ 3479.2.	3607.0 -3609.55 (2.55)	Shale, (N-4) medium dark grey to greenish-grey, smooth, clayey. Section has intermittent silty stringers (calcareous and non-calcareous). Muscovite is evident. Some Fe stains in the silty zones. 1 fracture @ N 40° E, and 1 @ N 50° E.
3481.3 -3481.7 (.4)	Silty layer, medium grey (N-5), non-calcareous, micaceous, homogeneous.	3609.55 -3611.9 (2.35)	Shale, indiscriminate and intermittent banding of N-3 and N-5 color around 3609-3610.0, silty non-calcareous zone 5" at 3611.0, some drusy pyrite is evident. 1 fracture @ N 45° E.
3481.7 -3483.1 (1.4)	Shale, banded dark grey to medium grey (N-3 to N-5), occasional silt stringer, frequent spore casts, micaceous and clayey. 2 fractures @ N 25° E.	3611.9 -3614.45 (2.55)	Shale, banded (N-3, N-4, and N-5) 1-2" intervals, some cross-bedding in the N-5, non-calcareous with some patches of drusy pyrite, N-5 is silty. 2 fractures @ N 45° E.
3483.1 -3486.1 (3.0)	Shale, medium grey (N-5) to greenish-grey (5 GY 6/1), banded with N-3 to N-5, occasional silt stringer, micaceous, clayey. 1 fracture @ N 40° E.	3614.45 -3617.05 (2.60)	Shale, banded, (same as above). 4 fractures @ N 45° E.
3486.1 -3489.9 (3.8)	Shale and siltstone, same as above, cross-bedded silt at 3488.0. 1 fracture @ N 45° E.	3617.05 -3619.75 (2.70)	Shale, intermittent calcareous silty (N-5) stringers randomly found in N-4 and N-3 shale, some Fe stain ½" at 3619.0'. A 1" N-5 silty calcareous zone at 3619.70. 1 fracture @ N 45° E.
3489.9 -3491.4 (1.5)	Shale and siltstone, same as above, greater than 65% siltstone in this interval, one non-calcareous silt layer .8 ft. thick at 3489.5, zone of "tear-up" loading features at 3489.4.		
3491.4 -3494.3 (2.9)	Shale with siltstone stringers, same as above, siltstone stringers becoming thinner, 50-50 silt/shale, non-calcareous.		

COTTAGEVILLE, W. VA. #11940

Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3619.75 -3622.5 (2.75)	Shale, 4" silty N-5 zone at 3620.0. Greenish-grey 5 GY 6/1 zone at 3620.5, interbedded layers of N-3 and N-4, a 2" silty calcareous (N-5) zone at 3622.0, small pyrite nodules present, micaceous. 1 fracture @ N 45° E.	3650.0 -3652.7 (2.7)	Shale, same as above. 2 fractures @ N 45° E.
3622.5 -3625.2 (2.7)	Shale, greenish-grey (5 GY 6/1), with silty calcareous nodules 1" present (N-5), Fe stain ½" at 3623.5, some drusy pyrite is found in patches, some micaceous material is present throughout. 1 fracture @ N 40° E.	3652.7 -3655.4 (2.7)	Shale, same as above, occasional pyrite nodules .5 cm. 3 fractures @ N 45° E.
3625.2 -3628.15 (2.95)	Shale, (N-4) with silty nodules, 1" of calcareous Fe silt found intermittently, silty stringers ½" at 3627.0, some drusy pyrite found also. 1 fracture @ N 40° E.	3655.4 -3658.0 (2.6)	Shale, same as above, occasional silt stringer (.5 cm) occasional carbonaceous fossil fragment, pyritic spore casts. 3 fractures @ N 45° E.
3628.15 -3630.9 (2.75)	Shale, interbedded N-5 and N-4 lenses with some silty N-5 ½" stringers, some N-3 zones 1" intermittently found. 3 fractures @ N 45° E.	3658.0 -3660.4 (2.4)	Shale, medium dark grey (N-4), zone of slightly silty medium grey (N-5) from 3659.0 to 3660.0, clayey, micaceous occasional pyritic fossil (brachiopod). 2 fractures @ N 45° E.
3630.9 -3633.55 (2.65)	Shale, same as above, with 1" iron stringer at 3633.3 non-calcareous. 2 fractures @ N 45° E.	3660.4 -3663.2 (2.8)	Shale, same as above, zone of medium grey (N-5) from 3662.7 to 3663.2. 3 fractures @ N 45° E.
3633.55 -3635.9 (2.35)	Shale, same as above, with more silty cross-bedded (Fe stained) zones at 3635.0, darker shale below 3635.0.	3663.2 -3666.2 (3.0)	Shale, same as above, no pyrite observed. 3 fractures @ N 45° E.
3635.9 -3638.65 (2.75)	Shale, same as above, with large silty N-5 zone at 3638.0, a dark N-3 area is between 3637 and 3638.0. 1 fracture @ N 45° E.	3666.2 -3668.8 (2.6)	Shale, same as above, occasional spore casts replaced with pyrite. 3 fractures @ N 45° E.
3638.65 -3641.40 (2.76)	Shale, interbedded thin beds 1-2" of N-3, N-4, N-5, a 6" silty calcareous zone at 3640. 1 fracture @ N 50° E.	3668.8 -3671.75 (2.95)	Shale, silty, medium grey (N-5), calcareous zone @ 3669.8 to 3670.5, abundant spores and spore casts. 2 fractures @ N 45° E.
3641.4 -3644.2 (2.8)	Shale, 9" N-5 silty, non-calcareous zone at 3642.0, N-3 (3642.5-3643.3), silty Fe zone 3644.0. 3 fractures @ N 45° E.	3671.75 -3674.9 (3.15)	Shale, silty, medium grey (N-5), calcareous 1 mm stringers throughout, occasional pyritic worm burrows, occasional fossil fragment. 2 fractures @ N 45° E.
3644.2 -3645.0 (.8)	Siltstone, partly calcareous, cross-bedded, iron stained.	3674.9 -3676.0 (1.1)	Shale, medium dark grey (N-4), micaceous, relatively uniform. 2 fractures @ N 45° E.
3645.0 -3647.0 (2.0)	Shale, medium grey (N-5), greenish, interbedded with cross-bedded siltstone, micaceous, occasional pyritic spore casts, drusy pyrite. 1 fracture @ N 45° E.	3676.0 -3679.5 (3.5)	Shale, medium grey (N-5), micaceous, relatively uniform. 3 fractures @ N 45° E.
3647.0 -3650.0 (3.0)	Shale, greenish grey (5 GY 6/1), clayey, with an occasional 1 cm silt stringer, not very micaceous. 2 fractures @ N 60° E, 2 @ N 45° E, and 1 @ N 65° E.	3679.5 -3683.5 (4.0)	Shale, medium dark grey (N-4), clayey, micaceous, occasional .3 cm pyrite nodules, relatively uniform throughout interval. 4 fractures @ N 45° E.
		3683.5 -3686.0 (2.5)	Shale, same as above, with occasional 1 cm zone of medium grey (N-5) slightly silty shale, no pyrite observed. 3 fractures @ N 45° E.
		3686.0 -3688.6 (2.6)	Shale, same as above, with occasional silt stringer and spore casts. 2 fractures @ N 45° E.

COTTAGEVILLE, W. VA. #11940

Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3688.6 -3692.4 (3.8)	Shale, same as above, except subtle banding with 2 cm layers of slightly silty medium grey (N-5). 5 fractures @ N 45° E.	3717.5 -3719.0 (1.5)	Shale, same as above, with occasional band of medium dark grey (N-4), and a pyrite stringer @ 3717.9. 1 fracture @ N 30° E, and 1 @ N 45° E.
3692.4 -3695.4 (3.0)	Shale, medium grey (N-5), slightly greenish, slightly silty in places, pyrite spore casts and possible burrowing, micaceous, occasional small 1-2 mm silt stringers and occasional band of medium dark grey (N-4). 3 fractures @ N 45° E.	3719.0 -3719.4 (0.4)	Shale, same as above with frequent 1-2 cm pyrite nodules.
3695.4 -3698.25 (2.85)	Shale, same as above, with banding and silt being more pronounced. 3 fractures @ N 45° E.	3719.4 -3721.15 (1.75)	Shale, medium dark grey (N-4), clayey, micaceous, occasional pyrite stringer, fractures are mineral filled (probably dolomite reacts slowly with .1 HCL), large carbonaceous layer at ≈ 3721.0. 2 fractures @ N 45° E.
3698.25 -3700.65 (2.4)	Shale, medium dark grey (N-4), clayey, micaceous, occasional 1 cm pyrite nodule, relatively uniform throughout interval. 2 fractures @ N 45° E.	3721.15 -3723.5 (2.35)	Shale, medium grey (N-5), same as above, including mineral filled fractures throughout. 2 fractures @ N 45° E and 1 @ N 45° W.
3700.65 -3703.35 (2.7)	Shale, .4 foot transition back to a medium grey (N-5), slightly greenish and slightly silty, micaceous, marine fossils observed at 3703.0, calcareous throughout most of interval. 3 fractures @ N 45° E.	3723.5 -3726.0 (2.5)	Shale, same as above, including mineral filled fracture throughout.
3703.35 -3705.0		3726.0 -3729.15 (3.15)	Shale, same as above, with mineral filled fractures, zone of medium dark grey (N-4) from 3727.4 to 3727.95, fossils (probably marine) at 3728.8. 1 fracture @ N 10° W, and 2 @ N 45° E.
3705.0 -3707.0 (2.0)	Shale, medium grey (N-5) to medium dark grey (N-4) banded indiscriminately, occasional stringers of pyrite nodules, occasional spore casts, micaceous. 2 fractures @ N 45° E.	3729.15 -3731.6 (2.45)	Shale, same as above, probable marine fossils continue to 3629.5, zone of medium dark grey (N-4) from 3730.3 to 3731.6. 2 fractures @ N 45° E, and 3 @ N 70° W.
3707.0 -3709.4 (2.4)	Shale, medium dark grey (N-4), clayey, micaceous, occasional pyrite nodule, 2 cm band of medium grey (N-5) @ 3707.1. 2 fractures @ N 45° E, and 1 @ N 35° E.	3731.60 -3734.20 (2.6)	Shale, medium dark grey (N-4), clayey, micaceous, large carbonaceous fossil @ 3732.4, zone of strange "spiraling shear" fractures @ 3733.0, band of medium grey (N-5) @ 3733.8.
3709.4 -3713.25 (3.85)	Shale, medium dark grey (N-4) to medium grey (N-5), banded, clayey to slightly silty, micaceous, occasional spore casts replaced with pyrite, calcareous zone @ 3712.5 to 3713.2. 3 fractures @ N 35° E, and 1 @ N 40° E.	3734.2 -3736.2 (2.0)	Shale, medium grey (N-5), clayey, micaceous, abundant pyritic spore casts, occasional .3 cm pyrite nodules, evidence of burrowing.
3713.25 -3715.0 (1.75)	Shale, same as above. 1 fracture @ N 25° E.	3736.2 -3738.8 (2.6)	Shale, medium dark grey (N-4), clayey, micaceous, uniform throughout interval, mineralized inclined fracture with slickensides @ 3737.7.
3715.0 -3717.5 (2.5)	Shale, medium grey (N-5), clayey, micaceous, occasional .3 cm pyrite nodule, relatively uniform throughout interval. 1 fracture @ N 25° E, 1 @ N 02° W, and N 30° E.	3738.8 -3740.75 (1.95)	Shale, same as above, without slickensides.
		3740.75 -3743.1 (2.35)	Shale, medium grey (N-5), same as above without slickensides. 1 fracture @ N 45° E.

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3743.1 -3746.0 (2.9)	Shale, medium dark grey (N-4) to medium grey (N-5), clayey, micaceous, uniform throughout interval, spore casts.	3773.15 -3775.3 (2.15)	Shale, same as above, without mineralized fractures.
3746.0 -3748.0 (2.0)	Shale, medium grey (N-5), same as above, intensely fractured, may be due to end of Run #5.	3775.3 -3777.1 (1.8)	Shale, medium dark grey (N-4), clayey, micaceous, occasional pyrite nodule, carbonaceous fossil fragments observed, uniform throughout interval.
3748.0 -3750.75 (2.75)	Shale, medium dark grey (N-4), clayey, micaceous, occasional pyrite nodule, uniform throughout interval. 1 fracture @ N 45° E.	3777.1 -3779.5 (2.4)	Shale, same as above, with occasional 1 mm silt stringer and spore casts replaced with pyrite.
3750.75 -3753.4 (2.65)	Shale, medium dark grey (N-4) to medium grey (N-5), banded, clayey, micaceous, slightly calcareous and silty zone at 3753.0. 3 fractures @ N 45° E.	3779.5 -3781.0 (1.5)	Shale, same as above.
3753.4 -3755.45 (2.05)	Shale, same as above, non-calcareous. 2 fractures @ N 45° E.	3781.0 -3784.0 (3.0)	Shale, same as above, with occasional fossil (pelecypod).
3755.45 -3757.95 (2.5)	Shale and calcareous shale, medium grey (N-5), silty to slightly silty, very calcareous to non-calcareous, micaceous. 3 fractures @ N 45° E.	3784.0 -3785.5 (1.5)	Shale, same as above, with slight amount of banding.
3757.95 -3758.75 (0.8)	Shale, same as above. 1 fracture @ N 70° E, and 1 @ N 05° E.	3785.5 -3786.2 (0.7)	Shale, medium grey (N-5), slightly silty, slightly calcareous in 1 mm stringers closely spaced, good marine fossils @ 3786.0.
3758.75 -3760.3 (1.55)	Shale, medium dark grey (N-4) to medium grey (N-5), occasional band of silt, occasional .5 cm pyrite nodule, micaceous, clayey.	3786.2 -3788.2 (2.0)	Shale, medium dark grey (N-4), clayey, micaceous, spore casts, uniform throughout interval.
3760.3 -3763.0 (2.7)	Shale, same as above, slight mineralization of fractures with probable dolomite.	3788.2 -3789.0 (0.8)	Shale, same as above, slightly mineralized fractures.
3763.0 -3765.4 (2.4)	Shale, same as above, occasionally becoming slightly silty. 1 fracture @ N 75° W, 2 @ N 05° E.	3789.0 -3791.0 (2.0)	Shale, medium dark grey (N-4) to medium grey (N-5), banded thinly, pyrite nodules, occasional 1 mm silt stringers, spore casts.
3765.4 -3767.65 (2.25)	Shale, medium dark grey (N-4), clayey, micaceous, uniform throughout interval. 2 fractures @ N 88° E.	3791.0 -3794.0 (3.0)	Shale, same as above, with 2 large 1-2 cm silty calcareous stringers.
3767.65 -3770.4 (2.75)	Shale, medium grey (N-5) to medium dark grey (N-4), clayey to slightly silty, micaceous, occasional stringers of pyrite, occasional 1-2 mm banding.	3794.0 -3796.0 (2.0)	Shale, medium dark grey (N-4), clayey, micaceous, occasional small fossil fragment, uniform throughout interval.
3770.4 -3773.15 (2.75)	Shale, medium dark grey (N-4), clayey, micaceous, pyrite nodules common, good development of mineralized fractures (probably dolomite).	3796.0 -3797.0 (1.0)	Shale, same as above, zone of medium grey (N-5) @ 3797.0.

APPENDIX B

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3220.0 -3222.4 (2.4)	Shale, medium dark grey (N-4), clayey, slightly micaceous, pyrite nodules and pyritized spore casts, large carbonaceous fossil fragment @ 3221.3, uniform in character throughout interval.	3249.9 -3250.6 (0.7)	Siltstone with shale, medium grey (N-5), small compaction loading structures, calcareous, micaceous, carbonaceous fossil fragments are common, occasional pyrite nodule.
3222.4 -3224.6 (2.2)	Shale, medium dark grey (N-4) to dark grey (N-3), clayey, slightly micaceous, pyritic with occasional pyritic spore casts (two 1 mm silty stringers observed), uniform character throughout interval.	3250.6 -3253.5 (2.9)	Siltstone (N-5), silty, pyrite present, calcareous, continuous lithology of siltstone to 3252.45'. Dark shale (N-4) at 3252.45'-3253.5'.
3224.6 -3226.7 (2.1)	Shale, medium dark grey to dark grey (N-4 to N-3), clayey, slightly micaceous, uniform character throughout interval.	3253.5 -3255.5 (2.0)	Shale (N-4), clayey (with some silt), slightly micaceous, some patches of darker (N-3) shale interbedded. Some thin stringers of silt ~ 3255.0.
3226.7 -3229.1 (2.4)	Shale, medium dark grey (N-4), same as above with occasional pyritic spore casts.	3255.5 -3258.0 (2.5)	Shale, medium dark grey (N-4), silty, silty bands of 1" ~ 3255.6. Dark shale is continuous to 3258.0. Slightly micaceous with thin laminations of silt.
3229.1 -3232.0 (2.9)	Shale, medium dark grey (N-4), silty, silty calcareous stringers (3229.1-3231.0'). Some pyrite at 3231.4'. Dark shale (1.0') N-3 to 3232.0'.	3258.0 -3260.9 (2.9)	Shale, dark grey (N-3), silty cross-bedded zone at 3258.7 (.2'). Very calcareous. Some pyrite stringers. Shale is continuous from 3259.3 to 3260.9 with pyrite laminated beds throughout with 1" silty stringers - 3260.7.
3232.0 -3234.1 (2.1)	Shale, medium dark grey (N-4), clayey, slightly micaceous, silty stringers (calcareous and Fe) at 3233.7. Darker shale (N-3) interbedded with stringers.	3260.9 -3263.7 (2.8)	Shale, medium dark grey (N-4), clayey, with 2 cm non-calcareous silt zones throughout the interval, micaceous zones with abundant carbonaceous fossil fragments are common, abundant pyritic spore casts observed.
3234.1 -3237.4 (3.3)	Shale, same as above, with thin calcareous pyritic stringers throughout the section. A 1" layer of light grey shale (N-5) at 3234.4'.	3263.7 -3266.1 (2.4)	Shale, medium dark grey (N-4), clayey, with occasional 1 cm silt stringer (one is calcareous), micaceous, pyritic spore casts are common.
3237.4 -3240.0 (2.6)	Shale, medium dark grey (N-4), clayey, pyrite globules at 3237.6'. Thin stringer (0.02') calcareous and iron stained at 3239.0'. Slightly micaceous with thinly laminated pyrite stringers.	3266.1 -3268.7 (2.6)	Shale, medium dark grey (N-4), clayey, with 9 2.5 cm silty zones @ 3266.2, slightly banded, with lighter areas being slightly silty, occasional pyrite nodule and spore casts, micaceous.
3240.0 -3242.8 (2.8)	Shale, medium dark grey (N-4), clayey, slightly micaceous, occasional 1 mm carbonaceous fossil fragment, 4 mm calcareous silt stringer @ 3241.7.	3268.7 -3271.2 (2.5)	Shale, medium dark grey (N-4), clayey, micaceous, uniform throughout interval.
3242.8 -3245.5 (2.7)	Shale, same as above, with an occasional pyrite nodule and two .3 ft. zones of cross-bedded silt @ ~ 3245.0.	3271.2 -3273.9 (2.7)	Shale (N-4), clayey-silty texture, micaceous, darker patches of shale N-3 found throughout, thin stringers (< .02') of silt (N-5) interspersed throughout the core.
3245.5 -3248.3 (2.8)	Shale, medium dark grey (N-4), clayey, slightly micaceous, pyrite nodules common, occasional .5 cm carbonaceous fossil fragment, 2 cm non-calcareous silt stringer @ 3246.7.	3273.9 -3276.7 (2.8)	Shale, medium dark grey (N-4), silty texture, same as above. Siltstone (.20') at 3276.5' (N-5) non-calcareous. Thinly laminated silty layers in this silty zone.
3248.3 -3249.9 (1.6)	Shale, medium dark grey (N-4), clayey, slightly micaceous, spore casts are common, uniform character throughout interval.		

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3276.7 -3279.0 (2.3)	Shale, medium dark grey (N-4), clayey, lithology is uniform throughout, some patches of (N-3) shale. Slightly micaceous and pyritic (drusy).	3304.8 -3307.1 (2.3)	Shale (N-4), silty texture, interbedded stringer of dark grey shale (N-3), with N-4 shale and silty stringers of N-5 non-calcareous with some iron stains.
3279.0 -3280.0 (1.0)	Shale (N-4), silty with thin silty stringers throughout. A .2' silty zone at 3279.8' and non-calcareous in nature.	3307.1 -3309.7 (2.6)	Shale (N-3), silty, non-calcareous zones of silt to 3308.0'. Some cross-bedding evident with iron stains present. Shale, N-4 with streaks of N-3 randomly dispersed throughout core. Some iron stained silt layers at 3309.6'.
3280.0 -3282.7 (2.7)	Shale, medium dark grey (N-4) to (N-5), clayey with some silt, some micaceous areas, some pyrite flakes, some gas present. Shale is uniform in this segment.	3309.7 -3312.3 (2.6)	Shale, medium dark grey (N-4), clayey, non-calcareous silty stringers (N-5) are found intermittently. Replacement pyrite is also present in spore casts.
3282.7 -3285.4 (2.7)	Shale (N-3, 4, 5), silty, alternating bands of silt and shale with pyrite stringers and nodules interspersed throughout the core. Drusy pyrite is also present.	3312.3 -3315.0 (1.7)	Shale and silty shale to siltstone inter-layered, medium dark grey to medium grey (N-4) to (N-5), micaceous, 6 cm layer of calcareous siltstone @ 3313.7, pyritic worm burrows, occasional carbonaceous plant fossil, occasional pyrite nodule.
3285.4 -3288.5 (3.1)	Shale (N-4), silty. Silty zone 0.8' at 3285.5'. Shale (N-3) stringers .05' at 3286.2' and 3287.8'. Silty zone at 3288.0'.	3315.0 -3317.0 (2.0)	Shale and silty shale to siltstone, same as above, with spore casts observed.
3288.5 -3291.0 (2.5)	Shale, medium dark grey (N-4) silty zones of thinly laminated silt stringers found ~ 3290.0'. Some micaceous areas and some carbonaceous fossils.	3317.0 -3317.7 (0.7)	Siltstone layer, .7' thick, medium grey (N-5), with intermittent calcareous zones, occasional pyrite nodule, micaceous, compaction loading features at 3317.0'.
3291.0 -3293.8 (2.8)	Shale, medium dark grey (N-4), clayey, with two 2 cm non-calcareous silt zones @ 3292.6' and 3293.4', micaceous, occasional spore cast.	3317.7 -3320.0 (2.3)	Siltstone, same as above, with small shale break at 3317.7 and 3319.8, also occasional carbonaceous fossil fragment.
3293.8 -3296.7 (2.9)	Shale, and silty shale, banded 1 cm medium grey to dark grey (N-5) to (N-3), medium grey is silty, dark grey is clayey, some cross-bedding, micaceous, pyritic zones, pyritic spore casts.	3320.0 -3322.8 (2.8)	Shale, silty shale, and siltstone, banded with medium grey (N-5) to dark grey (N-3), micaceous, some cross-bedding at 3322.6'.
3296.7 -3299.0 (2.3)	Shale, and siltstone, medium dark grey (N-4), clayey with intermittent silt stringers and a .8' calcareous siltstone layer @ 3298.2, micaceous, occasional spore casts.	3322.8 -3325.5 (2.7)	Shale, medium dark grey (N-4), silty. Silt zone of 1.0' more top with cross-bedding and iron stains. Shale and silty stringers are interbedded from 3323.9 to 3325.5'.
3299.0 -3301.3 (2.3)	Shale, and siltstone banded in 2-3 cm layers, medium grey to medium dark grey (N-5) to (N-4), some are calcareous, some are not, occasional cross-bedding, occasional pyritic spore casts.	3325.5 -3328.1 (2.6)	Shale (N-4), same as above, with fewer silty zones, slightly micaceous.
3301.3 -3304.8 (3.5)	Shale (N-4), silty interbedded zones (0.2') of silts and shale, silt zones are non-calcareous. Continuous shale (N-4) 3302.3'-3304.8'.	3328.1 -3331.7 (3.6)	Shale, same as above, with layered zones of silt (non-calcareous), with cross-bedding and iron stains. Some dark N-3 zones are evident (.02'). Spore casts are abundantly found with replacement pyrite.

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3331.7 -3333.5 (1.8)	Shale, medium dark grey (N-4), silty, with interbedded zones of silt and shale. Shale is N-3, N-4, and N-5. Non-calcareous, with some replacement pyrite.	3359.5 -3361.9 (2.4)	Shale, medium dark grey (N-4), slightly micaceous, pyritic spore casts common.
3333.5 -3336.4 (2.9)	Shale, silty shale, and siltstone interlayered, medium grey to dark grey (N-5 to N-3), pyritic, micaceous, occasional cross-bedding and loading features.	3361.9 -3364.5 (2.6)	Shale, medium grey (N-4), clayey, replacement spherical pyrite nodules in spore casts, micaceous, kerogen smell present.
3336.4 -3338.+ (1.6+)	Shale, silty shale, and siltstone, same as above, with occasional carbonaceous fossil fragment, and pyritic spore casts, abundant worm burrows.	3364.5 -3366.9 (2.4)	Shale, same as above, with silty zones ~ .1' intermittently evident throughout the section, non-calcareous, with replacement pyrite, dark grey (N-3) zones are present.
3338.+ -3340.5 (2.5)	Shale, and silty shale, medium grey to medium dark grey (N-5 to N-4), interlayered, micaceous, calcareous silt nodule @ 3339.5, pyritic.	3366.9 -3369.0 (2.1)	Shale, same as above, with N-3 stringers < .1' found throughout section. Thin silty laminations are found intermittently. Spore casts are evident, and drusy replacement pyrite is present.
3340.5 -3342.6 (2.1)	Shale and silty shale, same as above, with spore casts.	3369.0 -3371.5 (2.5)	Shale (N-4, N-5), clayey, same as above with drusy pyrite encrusted in several areas of this section.
3342.6 -3345.2 (2.6)	Shale, medium dark grey (N-4), silty with 0.8' zone of siltstone at 3342.6 and shale banded with N-3, N-4, and N-5 zones. Some micaceous patches and replacement pyrite evident.	3371.5 -3373.8 (2.3)	Shale, medium dark grey (N-4), slightly micaceous, uniform composition throughout interval.
3345.2 -3347.6 (2.4)	Shale, same as above, with 0.2' silty calcareous zones interbedded throughout. Some iron staining is evident in the silty zones, micaceous.	3373.8 -3376.1 (2.3)	Shale, same as above, with an occasional calcareous silty shale zone.
3347.6 -3349.9 (2.3)	Shale, same as above with less silty zones and fairly uniform N-4 shale. Little or no pyrite or muscovite.	3376.1 -3378.9 (2.8)	Shale, same as above, with one 3 cm calcareous silt layer @ 3378.0', occasional pyritic worm burrow observed, occasionally large - 5 cm carbonaceous plant fossil fragment, occasional 1 cm zone of cross-bedding.
3349.9 -3352.2 (2.3)	Shale (N-4), silty texture, with some silty stringers (calcareous), no pyrite or muscovite is evident.	3378.9 -3381.5 (2.6)	Shale and siltstone interbedded, medium dark grey to medium grey (N-4 to N-5), occasional pyrite nodules and pyritic spore casts.
3352.2 -3354.0 (1.8)	Shale and silty shale, medium grey (N-5) to medium dark grey (N-4), occasionally clayey, micaceous, slightly banded N-5 to N-4.	3381.5 -3384.1 (2.6)	Shale (N-4), with some zones (0.2') of N-3, finely micaceous flakes are seen throughout with some areas of spherical replacement pyrite in spore casts. Some non-calcareous silty stringers near 3384.0'.
3354.0 -3356.5 (2.5)	Siltstone, medium grey (N-5), micaceous, uniform character throughout interval.	3384.1 -3386.6 (2.5)	Shale, medium dark grey N-4), silty, silty zone near top of section. Stringers of N-3 shale are randomly found in bottom of section. Large nodules of pyrite are found at 3386.1'. Spore casts are evident.
3356.5 -3357.0 (0.5)	Shale, medium dark grey (N-4), siltstone stringer (2 cm) pinching out horizontally (may be loading feature), micaceous, .25 cm small carbonaceous fossil fragments, spore casts.	3386.6 -3389.4 (2.8)	Shale (N-3), clayey with zones of N-4 shale which have the appearance of loading. Shale is fairly uniform in section.
3357.0 -3359.5 (2.5)	Shale, medium dark grey to dark grey (N-4) to (N-3), clayey, micaceous, pyritic spore casts, shale becomes silty @ 3359.0'.		

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3389.4 -3391.9 (2.5)	Shale (N-4), clayey with zones of N-3 (.2') randomly found. Some silty zones are evident near bottom (non-calcareous). Some replacement pyrite (spherical).	3422.0 -3424.8 (2.8)	Shale and silty shale, same as above.
3391.9 -3394.7 (2.8)	Shale, silty shale and siltstone, banded, medium grey to dark grey (N-5 to N-3), pyritic, slightly micaceous.	3424.8 -3427.0 (2.2)	Shale, medium dark grey (N-4), silty texture with bands of N-4 and N-3 zones throughout the interval. Some micaceous material is evident.
3394.7 -3398.0 (3.3)	Shale, silty shale, and siltstone interlayered, same as above, with occasional cross-bedding.	3427.0 -3430.0 (3.0)	Shale, medium dark grey (N-4), clayey, thin stringers of silt are found throughout this section (non-calcareous). Some small bands of N-3 @ ~ 3429.0'. Some fossil casts are evident.
3398.0 -3400.4 (2.4)	Shale and silty shale interbedded with occasional silt stringers (calcareous), same as above.	3430.0 -3432.9 (2.9)	Shale, same as above, with calcareous silty stringers. N-3 shale is found @ ~ 3431.0'. Shale is fairly uniform in lithology.
3400.4 -3403.0 (2.6)	Shale, medium dark grey (N-4), slightly micaceous, pyritic, occasional calcareous silty zone.	3432.9 -3435.5 (2.6)	Shale, same as above, with N-5 lenses of shale containing iron, non-calcareous. Also, some N-3 zones are randomly found in this section.
3403.0 -3405.6 (2.6)	Shale, medium dark grey (N-4), clayey, with some micaceous areas. Silty zones are found at 3403.5' and 3404.0'. Both silts show cross-bedding and calcareous features.	3435.5 -3438.1 (2.6)	Shale, medium dark grey (N-4), slightly banded, micaceous, intermittent slightly silty zones, 2 cm siltstone layer @ ~ 3437.0'.
3405.6 -3408.2 (2.6)	Shale, medium dark grey (N-4), clayey, the texture is fairly uniform in this section. Some carbonaceous material is evident in the core. No silt is evident.	3438.1 -3440.9 (2.8)	Shale and silty shale, same as above, with a calcareous siltstone to silty shale zone beginning @ ~ 3440.3', slightly pyritic.
3408.2 -3410.9 (2.7)	Shale, medium dark grey (N-4), clayey with some silty zones found intermittently in this section. Zones are calcareous. Some pyrite is evident.	3440.9 -3443.7 (2.8)	Shale, and silty shale with siltstone layers interbedded, N-5 to N-4, micaceous, slightly banded, silty shale and siltstone zone (non-calcareous) from 3441.8' to 3443.0', slightly cross-bedded in places.
3410.9 -3413.6 (2.7)	Shale, medium dark grey (N-4), clayey with the texture uniform throughout the section. Some N-3 stringers are evident. Some micaceous material is evident.	3443.7 -3445.9 (2.2)	Shale, silty shale and siltstone, same as above, with cross-bedded calcareous siltstone @ 3445.5, and occasional spore casts.
3413.6 -3416.5 (2.9)	Shale, medium dark grey to medium grey (N-4 to N-5), with frequent calcareous zones, slightly micaceous, calcareous zones are slightly silty.	3445.9 -3448.5 (2.6)	Shale, medium dark grey (N-4), clayey, with bands of N-3 interspersed among the N-4 layers. Very few layers of silt (non-calcareous).
3416.5 -3419.4 (2.9)	Shale, same as above, but calcareous zones less frequent, occasional silt stringers, and a large 3 cm carbonaceous fossil fragment @ ~ 3417.5', slightly banded w/N-3 @ 3418.5'.	3448.5 -3451.0 (2.5)	Shale, medium grey (N-5), clayey, with loading @ ~ 3449.5'. There is banding of N-4 and N-5 shale.
3419.4 -3422.0 (2.6)	Shale and silty shale, medium grey to dark grey (N-5 to N-3), banded, non-calcareous, micaceous, occasional pyritic spore casts, banding is intermittent.	3451.0 -3453.8 (2.8)	Shale, medium dark grey (N-4) with clayey texture, .2-.3' bands of dark grey (N-3) shale randomly spaced in this section of core. Some cross-bedded silt zones.

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3453.8 -3455.0 (1.2)	Siltstone, medium grey (N-5), coarse texture throughout section, uniform lithology with little variation throughout interval, siltstone is very calcareous, very micaceous, and coarse.	3484.7 -3487.0 (2.3)	Shale, slightly silty, same as above, with a 5 cm calcareous-siltstone layer @ 3485.4.
3455.0 -3458.1 (3.1)	Shale, silty shale and silt stringers, medium grey to dark grey (N-5 to N-3), banded, frequently cross-bedded silt, micaceous, slightly pyritic.	3487.0 -3490.2 (3.2)	Shale, dark grey (N-3), clayey, with some grey black shale (N-2) and medium dark grey shale (N-4) scattered throughout, micaceous, some replacement pyrite is evident.
3458.1 -3461.0 (2.9)	Shale, silty shale and silt stringers, same as above, with less banding, occasional spore casts, large carbonaceous fossil fragment @ \approx 3460.6'.	3490.2 -3493.0 (2.8)	Shale, dark grey (N-3), same as above, with thin zones of N-4 shale @ \approx 3492.5', micaceous.
3461.0 -3463.7 (2.7)	Shale, medium dark grey (N-4), clayey, micaceous, occasional pyrite nodule, occasional 1 mm silt stringer, occasional small 2 mm carbonaceous fossil fragments.	3493.0 -3495.8 (2.8)	Shale, dark grey (N-3), clayey, with fairly uniform appearance. Some pyritic nodules are evident throughout the whole core.
3463.7 -3466.2 (2.5)	Shale, same as above, with a zone of 1 mm calcareous stringers @ \approx 3464.5.	3495.8 -3498.5 (2.7)	Shale, dark grey to medium dark grey (N-3 + N-4), clayey, section of core is uniform in color and texture. Some thin silty (non-calcareous) stringers are scattered throughout thin interval.
3466.2 -3469.1 (2.9)	Shale, dark grey (N-3), clayey with thin pyritic stringers. Some micaceous material. Shale changes to N-4 with bands of N-3 at 3467.0'. Some dark N-3 stringers are also present.	3498.5 -3501.5 (3.0)	Shale, medium dark grey to dark grey (N-4 to N-3), clayey, micaceous, occasionally pyritic.
3469.1 -3471.6 (2.5)	Shale, dark grey (N-3), clayey, some bands of N-4 \approx 3471.0'. Very thin, very calcareous, pyritic stringers are found in the N-3 zone.	3501.5 -3503.7 (2.2)	Shale, same as above.
3471.6 -3474.6 (3.0)	Shale, dark grey (N-3), clayey, with some N-2 zones evident. Pyrite globules are evident (non-calcareous) \approx 3472.9, micaceous. Section of core is fairly uniform.	3503.7 -3506.5 (2.8)	Shale, same as above.
3474.6 -3477.0 (2.4)	Shale, (N-3) dark grey, clayey, with occasional pyrite replacement. N-2 zones are also present, micaceous.	3506.5 -3508.5 (2.0)	Shale and silty shale, slightly greenish medium grey to medium dark grey (N-5 to N-4), calcareous micaceous, pyritic.
3477.0 -3479.6 (2.6)	Shale, medium dark grey (N-4), clayey. Micaceous, occasional pyrite nodules, becomes silty and calcareous @ \approx 3479.0'.	3508.5 -3509.0 (.5)	Shale, medium dark grey to dark grey (N-4 to N-3), clayey, micaceous.
3479.6 -3482.0 (2.4)	Shale, slightly silty, medium grey to medium dark grey (N-5 to N-4) slightly greenish, micaceous, slightly calcareous uniform character throughout interval.	3509.0 -3511.9 (2.9)	Shale, medium dark grey to dark grey (N-4 + N-3), clayey, bands of N-4 are found in the larger N-3 bands, slightly micaceous.
3482.0 -3484.7 (2.7)	Shale, same as above, but has a .8' zone of banding @ 3483.4 that contains interbedded medium dark grey and dark grey shale (N-4 and N-5) with no greenish tint and an occasional 1 cm silt stringer	3511.9 -3513.0 (1.1)	Shale, greyish black to dark grey (N-2 to N-3), light bands of N-4 are scattered throughout this section, slightly micaceous.
		3513.0 -3515.7 (2.7)	Shale, medium dark grey and medium grey (N-4 and N-5), clayey. N-4 is \approx 1.1' near top. N-5 is 1.1' on bottom with very calcareous shale. Some pyrite is evident. Some patches of grey black (N-2) are evident in N-4 shale.

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3515.7 -3518.4 (2.7)	Shale, medium dark grey (N-4), clayey, with calcareous material. N-3 zones (.1') are evident @ ~ 3517.8'. Loading features observed @ ~ 3517.5'.	3546.5 -3549.1 (2.6)	Shale (N-3, N-4), with thin pyritic stringers found in this darker shale. N-4, N-5 is found at 3548.5' with greenish-grey appearance.
3518.4 -3520.8 (2.4)	Shale, dark grey and medium dark grey (N-3 and N-4), non-calcareous with some bands of N-5 near 3520.0'. Some replacement pyrite is evident.	3549.1 -3551.2 (2.1)	Shale (N-4), clayey, with some silty zones. N-4 bands have "loading effect." There are N-3 bands throughout.
3520.8 -3523.5 (2.7)	Shale, dark grey (N-3) with some grey black (N-2), section of core is fairly uniform, non-calcareous, with some micaceous material present.	3551.2 -3553.7 (2.5)	Shale (N-3), clayey, section of core is fairly uniform with some muscovite available. Non-calcareous.
3523.5 -3526.2 (2.7)	Shale, medium dark grey (N-4), clayey in upper section of interval. Medium grey (N-5) shale in lower 1.2' with some calcareous zones evident.	3553.7 -3556.2 (2.5)	Shale (N-3), clayey, same as above with pyrite nodules scattered throughout this section.
3526.2 -3529.0 (2.8)	Shale, medium dark grey (N-4), clayey, with some medium grey (N-5) zones with loading structures. Some zones of N-3 ~ 3529.0' N-5 shale have green-grey appearance.	3556.2 -3559.0 (2.8)	Shale (N-3), clayey with N-4 nodules scattered throughout the core section. A band of N-5 (.3') is found at ~ 3557.8'. Loading is evident in this section. Larger pyrite nodules are present near bottom of core.
3529.0 -3531.7 (2.7)	Shale, medium dark grey to medium grey (N-4, N-5), clayey and silty areas. Bands of N-3 shale ~ 3530.9'. Pyrite stringers are present which are very calcareous. Some replacement pyrite also evident.	3559.0 -3561.7 (2.7)	Shale (N-3), same as above with large globules of replacement pyrite (non-calcareous).
3531.7 -3534.4 (2.7)	Shale, same as above with muscovite evident throughout the core section. Thin laminations of silt are present.	3561.7 -3564.6 (2.9)	Shale (N-2), clayey, with bands of N-5 (.3') found throughout the section. Some loading effects are seen in the N-5 bands. Kerogen odor is present in N-3 zones.
3534.4 -3537.5 (2.9)	Shale (N-4, N-5), texture is clayey, with zones of N-3 randomly found in core section. Micaceous material is evident also.	3564.6 -3566.8 (2.2)	Shale (N-4), medium dark grey, clayey, pyrite globules (non-calcareous). Some carbonaceous fossils (<.05'). Core is uniform in color and texture.
3537.5 -3540.0 (2.5)	Shale, N-4 same as above with intermittent bands of N-5, and N-3.	3566.8 -3569.0 (2.2)	Shale, medium dark grey (N-4 and N-5), clayey. N-5 shale appears at 3568.0', and is continuous, pyrite globules (.05') appear in the N-4 shale.
3540.0 -3543.0 (3.0)	Shale (N-5), texture is clayey, same as above with N-5 shale a greenish grey. Pyrite stringers are present (non-calcareous).	3569.0 -3571.8 (2.8)	Shale (N-5) medium grey, clayey, calcareous, with bands (.5') of N-4 medium dark grey which contain pyritic nodules and some micaceous material.
3543.0 -3544.5 (1.5)	Shale (N-5), with some N-3 bands. Thin stringers of silt-pyrite are present (non-calcareous). Muscovite is present.	3571.8 -3574.5 (2.7)	Shale (N-4) medium dark grey, clayey, with bands of N-5 (.3') and thin stringers of (N-3) dark grey. Some micaceous material in N-3, N-4.
3544.5 -3546.5 (2.0)	Shale (N-5), texture is silty and highly calcareous. There are many fractures filled with calcite, quartz, and others. Fractures may be worm burrows. Slickensides are present at 3545.0'.	3574.5 -3477.0 (2.5)	Shale (N-4), clayey, with sharp contact between silty (calcareous) zone (.1') and N-3 zone (.1'). Some loading features are present in greenish-grey (N-5) shale (slightly calcareous).

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3477.0 -3580.0 (3.0)	Shale (N-5) with one (.3') zone of N-3 shale (micaceous), and thin laminations (stringers) evident throughout the section. N-5 has greenish-grey appearance, (non-calcareous).	3606.1 -3608.7 (2.6)	Shale (N-4, 5) with zones of silty, calcareous N-5 shale. Interbedding of N-3, N-4. Micaceous material is present throughout section.
3580.0 -3583.2 (3.2)	Shale (N-4) clayey, with thin laminations of N-3. Large zone (1.2') of N-3 is present at 3500.0'. N-3 zone at 3582.8' (.5). N-3 zones have micaceous material. Some pyritic material is present.	3608.7 -3611.4 (2.7)	Shale (N-4) with zones of N-3 and N-5. Silty zones (.2') are found at 3608.9' and 3610.1' very calcareous.
3583.2 -3586.0 (2.8)	Shale (N-3) zone (1.0) at 3583.2', N-4 zone (.8'), N-5, 6 (.4') thin N-3 zone (.6') at bottom of section. Thin laminations of N-3 are evident throughout.	3611.4 -3614.0 (2.6)	Shale (N-3, 4) section is uniform in texture and color. Smell of kerogen is evident. Micaceous material is present.
3586.0 -3589.7 (3.7)	Shale (N-4), medium dark grey, thin laminations of N-3 and N-5 are evident throughout this section. Small carbonaceous specks are evident, along with micaceous material.	3614.0 -3617.0 (3.0)	Shale (N-4, 5) interbedding and laminations of each color. Clayey texture. Some dark patches of N-3 shale with micaceous flakes present.
3589.7 -3590.7 (1.0+)	Shale (N-4) same as above with kerogen odor in darker N-3 zones (non-calcareous).	3617.0 -3619.8 (2.8)	Shale (N-4), with silty texture, calcareous silty zones are evident. N-3 bands are evident near 3617.5' and 3619.0'. Sharp contacts are seen between silty N-5 and N-3 bands.
3590.7 -3593.1 (2.4)	Shale (N-4), with pyrite nodules scattered throughout. N-4 has gradational appearance into N-3 with (.05') calcareous stringer in the middle of section.	3619.8 -3622.6 (2.8)	Shale (N-4 and N-3), clayey texture. Bands of N-5 are evident around 3622.0'. Non-calcareous, some laminations of N-4, 5.
3593.1 -3596.0 (2.9)	Shale (N-4), silty, with pyritic nodules scattered, silty laminations are present and a silty zone (.1') (calcareous) with cross-bedding is evident at 3594.0'. Micaceous material is also evident.	3622.6 -3625.0 (2.4)	Shale (N-4), silty and clayey texture. Same as above.
3596.0 -3598.2 (2.2)	Shale (N-3), clayey, with kerogen odor. Micaceous particles are present along with minute (2-3 mm) carbonaceous fossils. Section is very uniform.	3625.0 -3628.0 (3.0)	Shale (N-3), silty with kerogen odor, micaceous material evident. Some thin bands of N-4 in fairly uniform section.
3598.2 -3600.8 (2.6)	Shale, (N-5) with thin laminations of N-4, N-3 randomly present. Some evidence of "loading" is seen ~ 3598.5'. Non-calcareous and slightly silty ~ 3600'.	3628.0 -3631.0 (3.0)	Shale (N-3 and N-2), clayey. Nodules of pyrite are evident in core. The section is very uniform in color and texture.
3600.8 -3604.4 (3.6)	Shale (N-3, 4) slightly silty, pyrite nodules are evident, kerogen odor is present and muscovite is scattered. Core section is very uniform in texture.	3631.0 -3633.9 (2.9)	Shale (N-2, N-3), dark uniform section with nodules of pyrite evident throughout. Non-calcareous pyrite.
3604.4 -3606.1 (1.7)	Shale (N-4) with dark grey (N-3) bands (.4') spaced intermittently in top of section. Silty zones are randomly found in N-4 zones. These zones are calcareous. There are pyrite nodules in N-3.	3633.9 -3636.5 (2.6)	Shale (N-3), clayey, micaceous. N-5, silty at 3634.5' (.8'). Thin bands of N-3 and thin laminations of N-4, N-5, with some silty stringers evident.
		3636.5 -3638.5 (2.0)	Shale (N-3) zone (1.4') with stringers of silty pyrite. Sharp contact between N-3 and N-4 without pyrite. N-4 fairly uniform 1.0' section to 3638.5'.
		3638.5 -3641.2 (2.7)	Shale (N-3, N-4, N-5), intermittent bands of ~ (.1-.3') with sharp contacts between each. Some silty textures are evident in N-5.

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Top- Bottom (Interval, ft)	Lithologic Description	Top- Bottom (Interval, ft)	Lithologic Description
3641.2 -3643.9 (2.7)	Shale (N-4, N-3), bands of each color - .2'-.7' with some pyrite nodules and stringers found in N-3 zones.	3672.9 -3675.6 (2.7)	Shale (N-4), darker greenish-grey laminations of (N-3, N-4, N-5). Evidence of differential loading is present. Core is consistent in appearance and texture.
3643.9 -3646.2 (2.3)	Shale (N-5, N-4, N-3) clayey, with some silt in N-5 zone. Bands of N-4 with fairly continuous N-3 zone at bottom with pyrite nodules present (non-calcareous).	3675.6 -3678.5 (2.9)	Shale (N-4), clayey, with greenish-grey (5 GY 6/1) laminations and bands. Loading is present in patches. Darker N-4 zone near 3675.7'.
3646.2 -3649.0 (2.8)	Shale (N-5) clayey with some silt. A N-3 zone (.3') is at 3645.5. A N-4 zone (.4') dimensions at 3648.6'.	3678.5 -3680.7 (2.2)	Shale (5 GY 5/1), greenish-grey, with laminations near top. Gradational bands of N-4 and N-5 ~ 3679. (1.8'). Laminations of N-4 and N-3 with "loading" evident ~ 3680.0'.
3649.0 -3651.9 (2.9)	Shale (N-3)(3649.0-3650.0') with pyrite nodules. Gradational zone shows N-5 shale (1.7') with greenish-grey appearance and it has pyritic zone with calcareous shale.	3680.7 -3683.7 (3.0)	Shale (5 GY 6/1), greenish-grey, highly calcareous shale, with silty zones stained with iron. N-3 laminations are seen throughout.
3651.9 -3654.5 (2.6)	Shale (N-5), clayey, with greenish- grey appearance, highly calcareous and section of core is uniform.	3683.7 -3686.5 (2.8)	Shale (N-4), clayey, non-calcareous some silty, but mostly the same as above section of core.
3654.5 -3657.4 (2.9)	Shale, (5 GY 8/1), medium light greenish- grey, clayey texture, silty calcareous, thin laminations of N-4 and N-5 in upper section (3654.5'-3655.4'). Thin calcareous silty stringers ~ 3656.0'. Iron stains are evident in section and silty zone is calcareous ~ 3657.0 (.2').	3686.5 -3688.7 (2.2)	Shale, (5 GY 6/1), greenish-grey with laminations of N-3. Band of N-3 ~ 3687.0'. Clayey texture and dark N-3 stringers.
3657.4 -3659.9 (2.5)	Shale (5 GY 6/1), greenish-grey, clayey, non- calcareous, laminations of N-4 and N-5 are evident. Core is fairly uniform with this description.	3688.7 -3690.0 (1.3)	Shale (N-4), clayey, same as above with thin laminations (.5') near bottom of section.
3659.9 -3662.7 (2.8)	Shale, (5 GY 6/1), greenish-grey, clayey, with some zones of silty calcareous shale (iron stains are evident in zones). Some banding of N-4 (.1') is intermittently found.		
3662.7 -3665.1 (2.4)	Shale, (5 GY 6/1), greenish-grey, clayey, non-calcareous, thin laminations of N-5 N-4, and N-3 shale. A dark band (.3') of N-3 shale at ~ 3658.0'. Silty non-calcareous stringers and nodules appear throughout.		
3665.1 -3668.0 (2.9)	Shale (5 GY 6/1), clayey, greenish-grey same as above with laminations of alternating N-5, N-4 and some N-3 shale. Non-calcareous. Some thin silty stringers are scattered.		
3668.0 -3670.3 (2.3)	Shale (5 GY 6/1), greenish-grey, same as above with darker N-3 stringers or laminations seen in this section.		
3670.3 -3672.9 (2.6)	Shale (N-4), silty calcareous zones 3670.3. Laminated grey (N-4 and some N-3, N-5). Non-calcareous to 3672.4. Lighter grey (N-5) with thin laminations found at 3672.4-3672.9 (non-calcareous).		